Claims

What is claimed:

1. A semiconductor device comprising:

a drain electrode;

a source electrode;

a channel contacting the drain electrode and the source electrode, wherein the channel includes zinc-indium oxide;

a gate electrode; and

a gate dielectric positioned between the gate electrode and the channel.

2 The semiconductor device of claim 1, wherein zinc-indium oxide includes a single-phase crystalline state of $Zn_xIn_{2y}O_{x+3y}$, wherein x and y are each independently in the range of about 1 to about 15.

3. The semiconductor device of claim 1, wherein zinc-indium oxide includes a mixed-phase crystalline state formed from compounds selected from the group consisting of ZnO, $Zn_xIn_{2y}O_{x+3y}$, In_2O_3, and mixtures thereof.

4. The semiconductor device of claim 3, wherein zinc-indium oxide includes $ZnO:Zn_xIn_{2y}O_{x+3y}:In_2O_3$ in a ratio of A:B:C, wherein A, B, and C are each in a range of about 0.025 to about 0.95.

5. The semiconductor device of claim 1, wherein zinc-indium oxide includes an amorphous form from compounds selected from the group consisting of ZnO, $Zn_xIn_{2y}O_{x+3y}$, In_2O_3, and mixtures thereof.

6. The semiconductor device of claim 5, wherein zinc-indium oxide includes an atomic composition of zinc and indium in a ratio of zinc(x):indium(1-x), wherein x is in the range of about 0.05 to about 0.95.

7. The semiconductor device of claim 1, wherein the channel includes being positioned between and electrically coupling the drain electrode and the source electrode.

8. The semiconductor device of claim 1, wherein at least one of the drain electrode, the source electrode, the channel, and gate electrode, and the gate dielectric are substantially transparent.

9. A semiconductor device, comprising:

a drain electrode;

a source electrode;

means for a channel to electrically couple the drain electrode and the source electrode;

a gate electrode; and

a gate dielectric positioned between the gate electrode and the channel.

10. The semiconductor device of claim 9, wherein the means for a channel includes means for a single-phase crystalline state of $Zn_xIn_{2y}O_{x+3y}$, wherein x and y are each independently in the range of about 1 to about 15.

11. The semiconductor device of claim 9, wherein the means for a channel includes means for forming a mixed-phase crystalline state from compounds selected from the group consisting of ZnO, $Zn_xIn_{2y}O_{x+3y}$, In_2O_3, and mixtures thereof.

12. The semiconductor device of claim 9, wherein the means for a channel includes means for forming an amorphous form from compounds selected from the group consisting of ZnO, $Zn_xIn_{2y}O_{x+3y}$, In_2O_3, and mixtures thereof.

13. The semiconductor device of claim 9, wherein at least one of the drain electrode, the source electrode, the channel, and gate electrode, and the gate dielectric are substantially transparent.

14. A method of forming a semiconductor device, comprising:

providing a drain electrode;

providing a source electrode;

depositing a channel contacting the drain electrode and the source electrode and including zinc-indium oxide;

providing a gate electrode; and

providing a gate dielectric positioned between the gate electrode and the channel.

15. The method of claim 14, wherein depositing a channel includes:

vaporizing a precursor composition; and

depositing the vaporized precursor composition using a physical vapor deposition technique.

16. The method of claim 15, wherein the physical vapor deposition technique includes one or more of dc reactive sputtering, rf sputtering, magnetron sputtering, and ion beam sputtering.

17. The method of claim 14, wherein depositing the channel includes depositing a precursor composition on the surface with an ink-jet deposition technique.

18. The method of claim 14, wherein depositing a channel includes:

providing a precursor composition including one or more zinc precursor compounds and indium precursor compounds and;

depositing the channel from the precursor composition.

19. The method of claim 14, including providing a substrate or substrate assembly; and

forming the semiconductor device on the substrate or substrate assembly.

20. A method of manufacturing a semiconductor device, comprising:

providing a drain electrode;

providing a source electrode;

step for providing a precursor composition including one or more zinc precursor compounds and indium precursor compounds;

step for depositing a channel including zinc-indium oxide from the precursor composition contacting the drain electrode and the source electrode;

providing a gate electrode; and

providing a gate dielectric positioned between the gate electrode and the channel.

21. The method of claim 20, wherein the step for depositing a channel includes:

step for vaporizing the precursor composition to form vaporized precursor composition; and

depositing the vaporized precursor composition using a physical vapor deposition technique.

22. The method of claim 21, wherein the physical vapor deposition technique includes one or more of dc reactive sputtering, rf sputtering, magnetron sputtering, and ion beam sputtering.

23. The method of claim 20, wherein the step for depositing the channel includes step for depositing the precursor composition with an ink-jet deposition technique.

24. A method of forming a channel, comprising:

providing a precursor composition including one or more zinc precursor compounds and indium precursor compounds; and

depositing the channel including zinc-indium oxide from the precursor composition to electrically couple a drain electrode and a source electrode.

25. The method of claim 24, wherein depositing the channel includes

vaporizing the precursor composition to form vaporized precursor composition; and

depositing the vaporized precursor composition between the drain electrode and the source electrode using a physical vapor deposition technique.

26. The method of claim 25, wherein the physical vapor deposition technique includes one or more of dc reactive sputtering, rf sputtering, magnetron sputtering, and ion beam sputtering.

27. A semiconductor device formed by steps, comprising:

providing a drain electrode;

providing a source electrode;

providing a precursor composition including one or more zinc precursor compounds and indium precursor compounds;

depositing a channel including zinc-indium oxide from the precursor composition to contact the drain electrode and the source electrode;

providing a gate electrode; and

providing a gate dielectric positioned between the gate electrode and the channel.

28. The semiconductor device of claim 27, wherein depositing the channel includes:

vaporizing the precursor composition to form vaporized precursor composition; and

depositing the vaporized precursor composition using a physical vapor deposition technique.

29. The semiconductor device of claim 28, wherein the physical vapor deposition technique includes one or more of dc reactive sputtering, rf sputtering, magnetron sputtering, and ion beam sputtering.

30. A method for operating a semiconductor device, comprising:

providing a semiconductor device that includes a drain electrode, a source electrode, a channel to electrically couple the drain electrode and the source electrode, wherein the channel includes zinc-indium oxide, a gate

electrode, and a gate dielectric positioned between the gate electrode and the channel; and

applying a voltage to the gate electrode to effect a flow of electrons through zinc-indium oxide of the channel.

31. The method of claim 30, wherein applying a voltage includes using the semiconductor device as a switch in a display device.

32. The method of claim 30, wherein applying a voltage includes conducting electrons through a channel of zinc-indium oxide in a linear region of operation.

33. A display device, comprising:

a plurality of pixel devices configured to operate collectively to display images, where each of the pixel devices includes a semiconductor device configured to control light emitted by the pixel device, the semiconductor device including:

a drain electrode;

a source electrode;

a channel contacting the drain electrode and the source electrode, wherein the channel includes zinc-indium oxide;

a gate electrode; and

a gate dielectric positioned between the gate electrode and the channel and configured to permit application of an electric field to the channel.

34. The display device of claim 33, wherein zinc-indium oxide includes a single-phase crystalline state of $Zn_xIn_{2y}O_{x+3y}$, wherein x and y are each independently in the range of about 1 to about 15.

35. The display device of claim 33, wherein zinc-indium oxide includes a mixed-phase crystalline state formed from compounds selected from the group consisting of ZnO, $Zn_xIn_{2y}O_{x+3y}$, In_2O_3, and mixtures thereof.

36. The display device of claim 35, wherein zinc-indium oxide includes $ZnO:Zn_xIn_{2y}O_{x+3y}:In_2O_3$ in a ratio of A:B:C, wherein A, B, and C are each in a range of about 0.025 to about 0.95.

37. The display device of claim 33, wherein zinc-indium oxide includes an amorphous form from compounds selected from the group consisting of ZnO, $Zn_xIn_{2y}O_{x+3y}$, In_2O_3, and mixtures thereof.

38. The display device of claim 37, wherein zinc-indium oxide includes an atomic composition of zinc and indium in a ratio of zinc(x):indium(1-x), wherein x is in the range of about 0.05 to about 0.95.

39. The display device of claim 33, wherein at least one of the drain electrode, the source electrode, the channel, and gate electrode, and the gate dielectric are substantially transparent.